

ABOUT THE ECOLOGICAL NICHES OF THREE BEECH  
LITTER PANPHYTOPHAGE ORIBATID MITES

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ОБ ЭКОЛОГИЧЕСКИХ НИШАХ ТРЕХ ОРИБАТИД-ПАНФИТОФАГОВ БУКОВОЙ ПОДСТИЛКИ

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Introduction

Achipteria coleoptrata (Linné), Nothrus silvestris Nicolet and Nannhermania elegantula (Berlese sensu /22/) are three panphytophage Oribatid mites among the most abundant species present simultaneously in the beech (Fagus silvatica Linné) litter of the biological reserve of La Tillaie, Fontainebleau Forest.

The plot studied has no herbaceous cover and its soil is a washed soil with a mull-modor type of humus /6/. Four layers were sampled from May 1971 to May 1972: litter of the year (L), litter-fermentation layer (F), humus-mineral layer ( $A_{11}H$ : 0-3 cm) and mineral layer ( $A_{11}$ : 3-6 cm) /4/.

On that soil the annual mean density of Oribatid mites is not very high, only about  $16\ 450\ m^{-2}$  /4/, from which about one fourth ( $3750\ m^{-2}$ ) corresponds to the annual mean density of the three species: A. coleoptrata,  $2250\ m^{-2}$ ; N. silvestris,  $1050\ m^{-2}$ ; and, N. elegantula,  $450\ m^{-2}$ .

Being panphytophages, these species play an important role in the decomposition of the beech litter feeding on leaf material as well as on bacteria and fungi /17,12/. Thus, as they were present in greater numbers in the same F layer, it seemed important to look at the possibility of identifying some of their ecological niche characteristics from periodical census data.

Niche Spatial and Temporal Components

Although N. elegantula, N. silvestris and A. coleoptrata coexist on a square meter area, this coexistence is not necessarily observed on a smaller area, the sample-unit ( $20\ cm^2$ ), which is more in relation with the size and the average low rate of daily displacement of this category of Oribatid mites

/5,10/. Thus, in only about 14-19% of the sample-units with at least one of these species present (183 out of 416), two species were present simultaneously, and in only about 8%, three ones. The double and the treble species-presence were more important in the F and A<sub>11</sub>H layers where the density of all the species but A.coleoptrata in A<sub>11</sub>H was higher: for the doubles about 10% of the sample-units in F and 2-6% in A<sub>11</sub>H, and for the trebles about 6% in F and 2% in A<sub>11</sub>H. No species coexistence was observed in the mineral layer.

The vertical distribution pattern of the three species differs (Table 1) which is synthesized by the Usher's mean depth /19/ and by Lebrun's vertical distribution (DV) index /11/. Though N.elegantula and N.silvestris are both mainly present in the F and A<sub>11</sub>H layers, N.elegantula is more a litter species than N.silvestris which seems more indifferent to the depth-organic matter factor. On the contrary, A.coleoptrata is typically a litter species, being much more abundant in the L layer than the other two species. The mean depths of N.elegantula and N.silvestris (2.20 and 2.50) were significantly different from that of A.coleoptrata (1.77) for the 13 months of observation, but for the same period the mean depth of N.elegantula was not significantly different from the one of N.silvestris: the difference was significant, however, for the period between May 1971 and January 1972 (Table 1).

These different patterns in the vertical distribution of the species can be translated in terms of spatial niche overlap measured by the Pianka's

T a b l e 1. Vertical distribution of N.elegantula, N.silvestris and A.coleoptrata

Vertical layers	N.elegantula (NEL), %	N.silvestris (NSI), %	A.coleoptrata (ACO), %
1 (L)	4.40	1.88	30.80
2 (F)	75.52	50.23	62.28
3 (A <sub>11</sub> H)	21.98	44.13	6.25
4 (A <sub>11</sub> )	1.10	3.76	0.67
DV index, %	23.08	47.89	6.92
Mean depth (13 months)	2.20	2.50	1.77
Mean depth (9 months: 05. 1971-01.1972)	2.21	2.51	1.81
NEL versus NSI (13 months)	$\chi^2 = 3.77$ Not significant		
NEL versus ACO (13 months)	$\chi^2 = 6.23$ Significant (P < 0.05)		
NSI versus ACO (13 months)	$\chi^2 = 9.31$ Highly significant (P < 0.01)		
NEL versus NSI (9 months)	$\chi^2 = 7.11$ Highly significant (P < 0.01)		

N o t e: Analysis of the differences between mean depths by the Friedman test /18/.

Table 2. Spatial niche overlap (Pianka's index,  $O_{ij}$ )

Pairs of species	Annual mean $\pm$ standard deviation	Amplitude
<i>N.elegantula</i> - <i>N.silvestris</i>	0.583 $\pm$ 0.224	0.139(JN.71) - 0.958(MR.72)
<i>N.elegantula</i> - <i>A.coleoptrata</i>	0.489 $\pm$ 0.177	0.251(JN.71) - 0.803(OT.71)
<i>N.silvestris</i> - <i>A.coleoptrata</i>	0.428 $\pm$ 0.212	0.149(JN.71) - 0.938(ST.71)

Note: JN.71 - June 1971; ST.71 - September 1971; OT.71 - October 1971; MR.72 - March 1972.

$O_{ij}$  index /16/: the highest niche overlap being that of the niches of *N.elegantula* and *N.silvestris* (about 60%) and the lowest that of the niches of *N.silvestris* and *A.coleoptrata* (about 40%) (Table 2).

The temporal component of the ecological niches of the three species were put in evidence by a multivariate analysis, the correspondance analysis /7/. Thus, in early autumn the juveniles of *N.elegantula* were absent from late autumn to late spring, an absolute dominance of the juveniles of *A.coleoptrata* was observed, and in summer some of the stages of *N.silvestris* were significantly present (deutonymphs and tritonymphs) or absent (larvae and adults).

#### Niche Female Potential Fecundity Component

The maximum number of eggs a gravid female can carry depends on the size of the female /21/. Thus, the maximum observed inside *N.elegantula* was three instead of four inside *N.silvestris* and *A.coleoptrata*. As some of the females present have no eggs inside, the number of eggs per female is lower than the mean number of eggs per gravid female: *N.elegantula*, 0.7 and 1.3; *N.silvestris*, 1.3 and 2.1; and, *A.coleoptrata*, 2.1 and 2.5.

The mean number of eggs per female (with or without eggs) varies all along the year and allows then a rough estimation of the number of eggs laid by month and square meter (Table 3). The highest mean number of eggs per female was for *N.elegantula* and *N.silvestris* higher in spring and early summer and for *A.coleoptrata* in winter and spring. This agrees with the observations made on a danish beech woodland by Luxton /13/. The density of the females being also higher at the same periods, the potential number of eggs to be laid can reach the maximum values, which means about 400 in May 1971 for *N.elegantula* (annual mean, 121  $m^{-2}$ ), about 3000 in June 1974 for *N.silvestris* (annual mean, 393  $m^{-2}$ ) and about 2000 in February 1972 for *A.coleoptrata* (annual mean, 637  $m^{-2}$ ).

#### Niche Adults Feeding Potential Component

The number of food boli present in the gut can give some idea of the feeding activity of a species /15/.

For *N.silvestris* the highest mean numbers were observed during the winter and the spring (January-May 1972: 2.25-3.00 boli per female) and the lowest values in autumn (October-November 1971: 0.57 and 0.33 boli per female). Concerning *N.elegantula* and *A.coleoptrata* females the lowest values were obser-

Table 3. Temporal fluctuations of the potential number of eggs laid by square meter

Months	<u>N. elegantula</u>		<u>N. silvestris</u>		<u>A. coleoptrata</u>	
	Mean	Number	Mean	Number	Mean	Number
	number of eggs/♀	of eggs laid	number of eggs/♀	of eggs laid	number of eggs/♀	of eggs laid
1971 May	1.20	378	2.20	693	2.25	563
June	0.67	127	2.47	2939	2.50	625
July	1.00	315	2.00	130	1.80	567
August	0.80	252	-	-	0.25	63
September	0.50	125	0.25	188	1.00	315
October	0	0	0.29	128	-	-
November	0.67	127	0	0	1.86	818
December	-	-	0	0	2.00	1000
1972 January	0	0	0	0	3.00	375
February	-	-	2.00	250	2.07	1811
March	1.00	65	1.00	65	3.00	375
April	0.25	63	1.67	317	2.57	1131
May	0.33	63	1.75	438	3.83	1436

Note. 0 - females present without eggs; (-) - no females present.

ved firstly in September 1971 (0.25 and 0.40 respectively) and afterwards in January 1972 (respectively 1.00 and 0.50) with a peak in November 1971 when the lowest value for N. silvestris was observed. The striking difference between N. elegantula and A. coleoptrata was that the mean number of food boli was greater in A. coleoptrata during the spring and the summer (May to September 1971) and in N. elegantula from the autumn to the early spring (October 1971 to April 1972).

#### Discussion and Conclusions

Although N. elegantula, N. silvestris and A. coleoptrata are present simultaneously and most abundant in the F layer some significant differences in the vertical distribution can be put forward. A. coleoptrata is more attracted by the litter during the year (litter species) than the other two species, N. elegantula being firstly more attracted by the fermentation layer and secondly by the humus-mineral layer (sub-litter species) and N. silvestris being present in almost the same proportions in the F and A<sub>1</sub>H layers (indifferent species). This seems in agreement with the observations made by other authors (/20,1,14/ and some others).

Though the size of N. elegantula is smaller (590x255  $\mu$ ) than that of N. silvestris (760x405  $\mu$ ), their vertical colonization of the substrate seems then not to be in direct correlation with the smaller porosity of the humus-mineral layer. (It is interesting to notice that the length of A. coleoptra-

ta (600  $\mu$ ) is close to the one of N.elegantula and that its width (395  $\mu$ ) is closer to that of the N.silvestris.

In terms of vertical distribution N.elegantula and N.silvestris are closer to each other than with A.coleoptrata, the niche overlap index being the highest observed. But, in terms of mean number of eggs per gravid female N.silvestris and A.coleoptrata are closer (2.10 eggs/Q versus 2.50 eggs/Q) than with N.elegantula (1.26 eggs/Q). However, the fecundity tendency and the potential number of eggs to be laid are higher for N.elegantula and for N.silvestris at the same season (spring and early summer) and for A.coleoptrata later in the year becoming more spread during the winter and the spring. This type of fecundity activity and the duration of development can be one of the reasons why the mean population densities per square meter are quite different.

An other important aspect of the difference between the ecological niches of these species is certainly the trophic one. From the census data it is difficult to characterize it. However, counting the number of food boli present in the gut at different times of the year some relative differences can be detected which can suggest the season when the suitable food is available. The best feeding months seem to be those of the winter and the spring for N.silvestris and those of the spring and the summer for N.elegantula and A.coleoptrata females. For A.coleoptrata males no dominant season was detected.

Anderson /2/ found some evidence that the trophic separation of the Oribatid mites was related to the mean body size of them, which is the case of the panphytophage species N.elegantula and N.silvestris. However, other trophic differences between these two species were found experimentally in laboratory. In the presence of pure cellulose attacked by cellulolytic fungi and of the soil underneath, N.elegantula was 2.5 times more important in the cellulose than in the soil and 1.3 times more important in this substrate than N.silvestris. On the contrary, in the soil N.silvestris was about 4 times more important than on the cellulose and about 7 times more important than N.elegantula /9/. If the main feeding preferences towards the cellulolytic fungi seemed to be Oidiodendron echinulatum Barron for both mite species, N.elegantula was secondary more attracted by Chrysosporium pannorum (Link) Hughes and N.silvestris by Cordana pauciseptata Preuss /8/.

According to /12/, beech leaves, black sterile mycelium and Cryptococcus albidus are the main preferences of N.silvestris which is not attracted by Phoma sp. and Aureobasidium pullulans (de Bary) Arnaud, common on the surface litter (L layer). Nevertheless, these two fungi are strongly preferred by A.coleoptrata together with the black sterile mycelium and C.albidus. Then, the localization of A.coleoptrata in the L layer and that of N.silvestris in the fermentation zone (F layer) can be predicted by these feeding preferences /14/.

The type of microhabitats with their spatial and food characteristics is certainly one of the most important factors in the separation of the ecological niches of the soil Oribatid mites. These microhabitats are normally distributed in a mosaic /3/. Then, A.coleoptrata, N.silvestris and N.elegantula can coexist easily.

## References

1. Anderson J.M. Observations on the vertical distribution of Oribatei (Acarina) in two woodland soils // Organismes du sol et production primaire (C.R. IV Colloq. Intern. Faune du Sol) / Eds. J.D'Aguilar, C.Athias-Henriot, A.Bessard, M.B.Bouche, M.Pussard. I.N.R.A., Paris, 1971. P.1-15.
2. Anderson J.M. Succession, diversity and trophic relationships of some soil animals in decomposing leaf litter // J. Anim. Ecol. 1975. Vol.44. P. 475-495.
3. Anderson J.M. The organization of soil animal communities. Soil organisms as components of ecosystems // Proc. VI. Intern. Soil Zoology Colloq. / Eds. U.Lohm, T.Persson. Ecol. Bull. (Stockholm). 1977. Vol. 25. P. 15-23.
4. Athias-Henriot C., Cancela da Fonseca J.P. Microarthropodes édaphiques de la Tillaie (Forêt de Fontainebleau). Composition et distribution spatiotemporelle d'un peuplement en placette à litière de hêtre pure (Acariens et Collembolés) // Rev. Ecol. Biol. Sol. 1976. Vol. 13. P.315-329.
5. Berthet P. Field study of the mobility of Oribatei (Acari), using radioactive tagging // J. Anim. Ecol. 1964. Vol. 33. P. 443-449.
6. Bouchon J., Faille A., Lemme G., Robin A.M., Schmitt A. Cartes et notices des sols, du peuplement forestier et des groupements végétaux de la réserve biologique de la Tillaie en forêt de Fontainebleau // Laboratoire d'Ecologie Végétale, Université Paris XI, Orsay. 1973. P. 1-12, 3 cartes.
7. Cancela da Fonseca J.P. Quelques approches analytiques en dynamique de populations édaphiques (Acariens Oribates) // Rev. Ecol. Biol. Sol. 1980. Vol. 17. P. 445-477.
8. Cancela da Fonseca J.P., Kiffer E., N. Poinso-Balaguer Sur les rapports entre Microarthropodes et Micromycètes d'un sol forestier. II. Quelques observations sur les Acariens Gamasides (non Uropodes) et les Collembolés // Rev. Ecol. Biol. Sol. 1979. Vol. 16. P. 181-194.
9. Kiffer E., J.P. Cancela da Fonseca Sur les rapports entre Microarthropodes et Micromycètes d'un sol forestier // Zbl. Bakteriologie. 1971. Vol.126. P. 510-520.
10. Lebrun Ph. Contribution à l'étude écologique des Oribates de la litière dans une forêt de Moyenne-Belgique // Mem. Inst. roy. Sc. nat. Belg. 1965. Vol. 153. 96 P.
11. Lebrun Ph. Ecologie et biocénose de quelques peuplements d'arthropodes édaphiques // Mem. Inst. roy. Sc. nat. Belg. 1971. Vol. 165. 203 p.
12. Luxton M. Studies on the oribatid mites of a danish beech wood soil. I. Nutritional biology // Pedobiologia. 1972. Bd. 12. S.434-463.
13. Luxton M. Studies on the oribatid mites of a danish beech wood soil. IV. Developmental biology // Pedobiologia. 1981a. Bd. 21. S. 312-340.
14. Luxton M. Studies on the oribatid mites of a danish beech wood soil. V. Vertical distribution // Pedobiologia. 1981b. Bd. 21. S. 365-386.
15. Mitchell M.J., Parkinson D. Fungal feeding of Oribatid mites (Acari: Cryptostigmata) in an aspen woodland soil // Ecology. 1976. Vol. 57. P. 302-312.
16. Pianka E.R. The structure of lizard communities // Ann. Rev. Ecol.Syst. 1973. Vol. 4. P. 53-74.

17. Schuster R. Der Anteil der Oribatiden an der Zersetzungs Vorgängen im Boden // Z. Morph. Ökol. Tiere. 1956. Vol. 45. P. 1-33.
18. Siegel S. Non-parametric statistics for the behavioral sciences // McGraw-Hill. N.Y., 1956. 312 p.
19. Usher M.B. Seasonal and vertical distribution of a population of soil arthropods: Cryptostigmata // Pedobiologia. 1975. Bd. 15. S. 364-374.
20. Van der Drift J. Analysis of the animal community in a beech forest floor // Tijdschr. Ent. 1951. Vol. 94. P. 1-168.
21. Webb N.R., Elmes G.W. Variations between populations of Steganacarus magnus (Acari; Cryptostigmata) in Great Britain. Pedobiologia. 1979. Bd. 19. S. 390-401.
22. Willmann C. Moosmilben oder Oribatiden (Oribatei) // Die Tierwelt Deutschlands. 1931. Bd. 22. S. 79-200.